RAMS

Ram Angle and Magnetic Field Sensor

AT A GLANCE

What is it?

The Ram Angle and Magnetic Field Sensor (RAMS) is a PicoSat-compatible attitude sensor based on sensing the ram direction.
Volume: 5 × 5 × 10 cm
Mass: 535 g (CubeSat Version)
Power: 1.0 W

How does it work?

RAMS measures the cross-track neutral (or ion) wind and couples that measurement with a magnetometer measurement to provide continuous attitude knowledge relative to the local orbit frame.

What will it accomplish?

RAMS offers a novel in-situ attitude sensor capable of measuring a fundamental quantity inherent to every Earth-pointing satellite… the ram (or forward) direction. The ram direction is observable continuously (unlike the Sun direction), regardless of roll angle (unlike the Earth direction).

Space Science Division (SSD)

The SSD's focus is to discover, develop, and demonstrate innovative technologies, methods, and products that are needed to ensure robust access to space-associated capabilities of critical importance. The Division combines assimilative environmental specification and forecast models and related optimized suites of remote and in situ sensors, with scientific theory and analysis, and operationally derived performance metrics, to increase technology readiness and foster transition.

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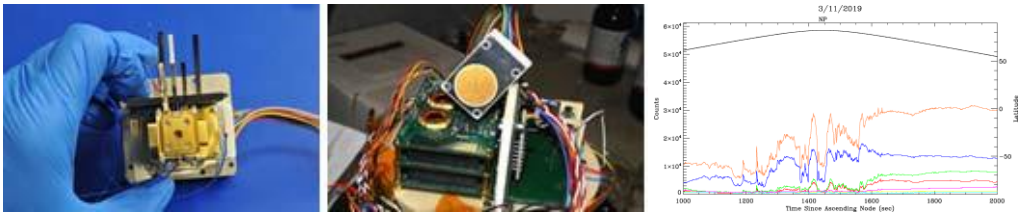

Flight Hardware & Data for the RAMS instrument, from left to right: sensor head, sensor electronics and anode, and flight data. RAMS in Sat-5 suffered a short circuit which prevented one power supply from working. We were unable to run in neutral mode or change the focus in the drift region. We have isolated and fixed the issue and are ready to fly again.

Objectives

NRL is the principal investigator institution on an effort to develop a low size, weight, and power (SWaP) in-situ sensor sponsored by the Office of Naval Research (ONR) to measure the RAM direction and use it as an attitude control input. The sensor under development will be compatible with CubeSat.

Approach

RAMS uses a small magnetometer combined with a quad-collector geometry with incidence axis aligned to a rigid satellite reference to obtain the centroid of the neutral and ion flux distributions with respect to the satellite velocity. This method provides estimates of the neutral wind (W) and ion-drift (V) components perpendicular to the spacecraft velocity. Splitting two of the quad anodes makes it possible to also estimate the neutral and ion temperatures (T). The suite includes a small 3-axis magnetometer for measurements of the magnetic field (B). Finally, the total collected currents of the ionized neutrals and the incident ions give the neutral and ion densities (n).

	Measurements Capabilities			
	Parameter	**Range**	**Resolution**	**Accuracy**
Neutrals	W_{perp}	1-1000 m/s	0.5 m/s	±0.5 m/s
	T_n*	500-5000 K	50 K	±50 K
	n_n**	10^2-10^{10} cm^{-3}	10 bit	±30 %
Ions	V_{perp}	1-1000 m/s	0.5 m/s	±0.5 m/s
	T_i	500-5000 K	50K	±50 K
	n_i	10-10^7 cm^{-3}	10 bit	±3 %***
	B	±800 µTesla	26 nT	20 nT

* Based on modeled relative composition, e.g., O, N_2, He, etc.
** Ion source sensitivity ~0.1/mA adjustable electron beam.
***Based on laboratory electrometer calibration.

Payoffs

The initial demonstration flight of RAMS will be on the Department of Defense Space Test Program (STP) STPSat-5. The RAMS instrument was delivered for integration to the spacecraft in September 2016. The STPSat-5 spacecraft launched Dec 2018 and operated through Oct 2020. An electrical short limited the sensor to partial validation on this flight. A demonstration with active control on a CubeSat is anticipated on a future flight.